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NASA TECH BRIEF

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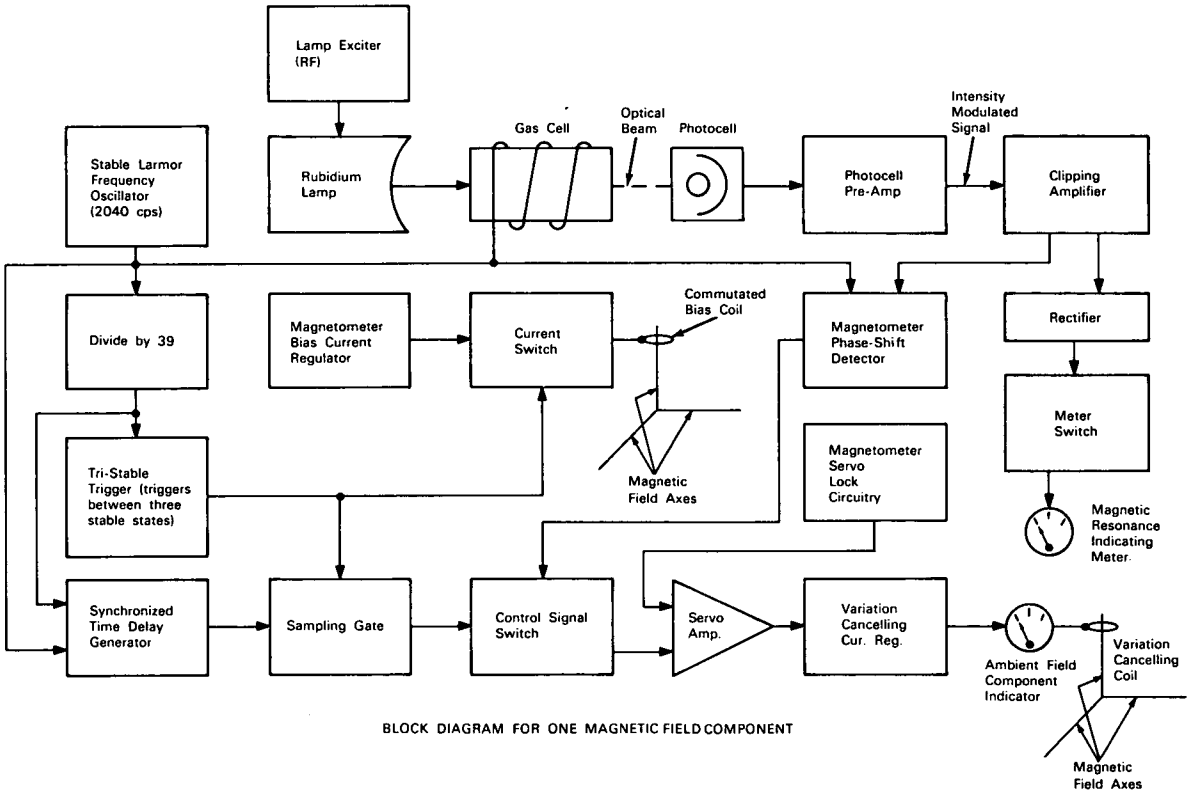
Magnetometer Measures Orthogonal Components of Magnetic Fields



BLOCK DIAGRAM FOR ONE MAGNETIC FIELD COMPONENT

The problem: To devise a magnetometer that will accurately measure the components of a low-strength magnetic field (such as that of the earth) in each of three mutually perpendicular directions.

The solution: A driven magnetometer employing the principle of magnetic resonance in optically pumped rubidium vapor. It incorporates a rubidium vapor cell (gas cell) surrounded by magnetic field bias coils disposed along the three axes of measurement. A phase detector generates a signal proportional to the magnitude and direction of the ambient magnetic field.

How it's done: A gas cell containing rubidium vapor is irradiated by a beam of optical resonance radiation from the rubidium vapor lamp, thus aligning the electron spins of the gas-cell atoms along the direction of the beam. The resultant net magnetic moment in the gas cell precesses about any steady ambient magnetic field at a frequency which varies accurately and sensitively with variations in the intensity

(continued overleaf)

(without regard to direction) of the magnetic field.

A known bias field is sequentially applied (commutated) to each of the three orthogonal bias coils, and the intensity modulation of the optical beam is detected by a photocell. Simultaneously, an alternating magnetic field is applied to the gas cell at a frequency equal to the Larmor magnetic resonance frequency of the gas cell atoms in the known bias field. The detected intensity modulation signal, after undergoing amplification and clipping, is compared to the alternating magnetic field signal by a phase detector during each cycle of the commutated bias field. If any ambient magnetic field (in addition to the known bias field) exists along a particular axis there will be a phase shift and the phase detector will generate a signal proportional to the magnitude of the ambient field vector.

The phase detector output is sequentially sampled by means of a three-state trigger and a sampling gate for each axis. The signal proportional to the phase shift (ambient magnetic field) drives a set of servo-controls which feed three variation-cancelling coils, thus reducing the total field to zero. The required current for each coil is a measure of the magnetic field component along each axis.

Notes:

1. In order to eliminate noise, the commutator switching is made synchronous with the alternating magnetic field signal.
2. This magnetometer should be useful in the measurement of magnetic fields where accurate three-component data are required. Specific applications include earth-field compensation for magnetic test coils and studies of magnetic anomalies in the earth's magnetic field.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10315

Patent status: NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Spectra Physics under contract to
Goddard Space Flight Center
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